Static and Dynamic Pupillometry Changes After Uneventful Phacoemulsification Surgery

Asker Bulut[1], *Alper Halil Bayat*[2]

ABSTRACT

Purpose: To compare postoperative changes in static and dynamic pupil size after uneventful phacoemulsification surgery.

Materials and Methods: 70 eyes of seventy patients (34 women and 36 men), who underwent phacoemulcification surgery were included in the study. Static and dynamic pupillometry measurements were examined and recorded in patients who were diagnosed with cataract and planned for surgery in the preoperative period without using mydriatic drops. Follow up controls were examined on the 1st day, 1st week and 1st month after cataract surgery. Pupillometry measurements were examined again in the examination at the 1st month control. The Aladdin® (Topcon, Tokyo, Japan) system was used for the measurement of pupillometry. Preop and postop first month pupillometry measurements were recorded and compared.

Results: The minimum value of dynamic PD was 3.29±0.94 mm before cataract surgery, which decreased to 3±0.86 mm after cataract surgery ($p = 0.016$). The maximum value of dynamic PD was 4.12±0.84 mm before cataract surgery, which decreased to 3.88±0.73 mm after cataract surgery ($p = 0.01$). Mesopic PD was 3.75±0.83 mm before cataract surgery, and it decreased to 3.41±0.59 mm after cataract surgery ($p < 0.001$). Photopic PD was 3.22±0.73 mm before cataract surgery, and it decreased to 2.82±0.63 mm after cataract surgery ($p < 0.001$).

Conclusion: Phacoemulsification surgery changes the static and dynamic PD due to possible changes in ACD, postoperative anterior chamber reaction and topical drops used.

Keywords: cataract surgery, pupil diameter, anterior chamber, pupil changes.

INTRODUCTION

Aladdin® (Topcon, Tokyo, Japan) is an optical low-coherence interferometer (OLCI) introduced in 2012 that can automatically measure anterior chamber depth (ACD), axial length (AL), pupillometry, white-to-white, keratometry, and corneal topography. For pupillometry, the device uses infrared light-emitting diode (LED) and white LEDs to assess both the photopic and mesopic pupil size.[1] As a standard part of the preoperative clinical examination of patients undergoing cataract operation, ocular biometric measurements are obtained to determine the intraocular lens power.[2] Pupillometry results are also a sub-component of ocular biometry measurements.[1] Postoperative changes in pupil diameter (PD) and pupil placement affect the success of the operation.[3] In addition, after cataract surgery, PD change plays an important role in achieving the best-corrected visual acuity.[4] However, only pupil size and shape are of clinical significance in achieving the best visual acuity following cataract surgery.[3]

Clearly, all patients undergoing cataract operation have different anatomical and functional characteristics owing to differences in pupil size and shape. The dilatation sizes and stages of pupils differ with individuals owing to the side effects of long-term drug use, anterior uveitis sequelae, and previous trauma. Accordingly, the anatomical structure of the eye should be carefully evaluated before cataract surgery. In addition, it should be noted that few specific lenses, particularly multifocal intraocular lens (IOL), cannot be used in patients with high kappa angles. Moreover, assessing PD in different light environments and comparing it with simultaneous corneal topography and diameter will help in planning the operation and will

1- Assist. Prof. MD, Department of Ophthalmology, İstanbul Medipol University, İstanbul, Turkey

2- Uz. Dr., Department of Ophthalmology, İstanbul Medipol University, İstanbul, Turkey

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Correspondence Adress:
Asker Bulut
İstanbul Medipol University, Department of Ophthalmology, İstanbul, Turkey
Phone: +90 212 912 2525
E-mail: abulut@medipol.edu.tr

positively affect the success after surgery. In an aspheric lens, perfect centration is not as important. However, PD, pupil shape, and central placement of the lens are important for patient satisfaction in toric and multifocal IOLs.[5]

The current study aimed to establish changes in static and dynamic pupillometry results after cataract surgery using the Aladdin ocular biometric system, which allows the evaluation of static and dynamic pupil size and PD.

MATERIALS AND METHODS

This prospective study enrolled 70 eyes from 70 patients (34 females and 36 males) who were undergoing cataract removal surgery. Written informed consent was obtained from all volunteer participants. The study received approval from the Ethics Committee of Istanbul Medipol University (protocol number: 157). All relevant principles of the Declaration of Helsinki were adhered to throughout the time of study data collection. For patients who were diagnosed with cataract and scheduled for surgery, measurements of intra ocular lens power as well as results of static and dynamic pupillometry were obtained in the preoperative period without using mydriatic drops. Subsequently, pupil dilatation was performed using mydriatic drops, and then a detailed anterior segment and fundus examination was performed. The exclusion criteria were as follows: any eye or systemic disease affecting PD or the pupil's response to light; patients developing complications during surgery; patients with anisocoria, parasympathetic denervation, or other pupillary defects; and use of drugs affecting normal light response of the iris such as cyclopentolate, tropicamide, prostaglandins, pilocarpine, nonsteroidal anti-inflammatory drugs, and narcotics. All patients included in the study were operated by a single surgeon (B.A.). Follow-up controls were examined on the 1st day, 1st week, and 1st month after cataract removal surgery. At these follow-up timepoints, full ophthalmological examinations including intraocular pressures, anterior segment, best-corrected visual acuity, and fundus examinations were performed and recorded. In addition, pupillometry was conducted again at the 1st month follow-up control. The Aladdin® (Topcon, Tokyo, Japan) system was used for pupillometry. Pre- and 1-month postoperative pupillometry results were recorded and compared using IBM-SPSS version 22.0 program and paired sample t-test.

Surgical Technique

All individuals included in the study were operated by the same surgeon (B.A.) at the same hospital. All patient eyes were dilated using mydriatic drops before surgery. Topical anesthesia was applied for all surgeries. Following surgical area cleaning, a 2.8-mm limbal corneal incision was created in the axis of 135°, and the anterior chamber was filled with 1.6% sodium hyaluronate. Then, the nucleus was subjected to phacoemulsification using torsional ultrasound (Centrion Vision System, Alcon Surgical, Inc.). Subsequently, irrigation and cortex aspiration were performed, and the IOL was implanted within a bag in all eyes. During the postoperative period, all patients were planned to be treated with moxifloxacin drop (5 drops once a day) and dexamethasone drop (5 drops once a day) for 4 weeks.

Measurements

Planning treatment helps avoid any negative surprises in patients who are scheduled to receive toric and multifocal IOLs with full pupillometry scanning feature and in patients who are scheduled for refractive surgery. It is important to evaluate pupil size under different light conditions, especially among patients scheduled for refractive surgery, as well as to consider excessively large, small, or decentralized pupils.[5]

In our study, each eye underwent a detailed anterior segment and fundus examination. ACD, AL, pupillometry, white to white, keratometry, and corneal topography were measured using Aladdin® (Topcon, Tokyo, Japan), an OLCI device released in 2012. For pupillometry, LED and white LEDs were used to assess photopic and mesopic pupil sizes. Preoperatively and 1 day, 1 week, and 1 month postoperatively, the following assessments were performed: best-corrected distance visual acuity,

Table 1: *Changes in pupillometry and ACD values after cataract surgery.*

	Preoperative	Postoperative	Changes	P value*
Minimum PD (dynamic)	3.29±0.94	3±0.86	-0.28±0.97	p=0.016
Maximum PD (dynamic)	4.12±0.84	3.88±0.73	-0.24±0.77	p=0.01
Mesopic PD	3.75±0.83	3.41±0.59	-0.34±0.67	p<0.001
Photopic PD	3.22±0.73	2.82±0.63	-0.4±0.78	p<0.001
ACD	3.10±0.26	3.58±0.24	+0.47±0.19	p<0.001

ACD: Anterior chamber depth, PD: pupil diameter, *Paired Samples T Test anterior segment determined by biomicroscopy, dilated pupil detailed fundus examination, intraocular pressure measurement, and corneal endothelial cell intensity.

For all patients, pupillometry results were obtained by a single physician using the Aladdin® (Topcon, Tokyo, Japan) device preoperatively and 1-month postoperatively. A computerized automatic pupillometry system was used, which was equipped with infrared LED and white LEDs to assess photopic and mesopic pupil size.

Statistical Analysis

IBM-SPSS version 22.0 was used for statistical analysis. Chi-square test was to compare categorical variables. Student's *t*-test was used to compare continuous variables. Results with a p value of <0.05 were considered statistically significant.

RESULTS

Of all participants, 34 (48%) were female and 36 (52%) were male, with a mean age of 62.12±6.56 years. The mean age was 62.11±7.43 years for females and 62.14±5.66 for males (p=0.986).

The minimum value of dynamic PD was 3.29±0.94 mm before cataract surgery, which decreased to 3±0.86 mm after cataract surgery (p=0.016). The maximum value of dynamic PD was 4.12±0.84 mm before cataract surgery, which decreased to 3.88±0.73 mm after cataract surgery (p=0.01). Mesopic PD was 3.75±0.83 mm before cataract surgery, and it decreased to 3.41±0.59 mm after cataract surgery (p<0.001). Photopic PD was 3.22±0.73 mm before cataract surgery, and it decreased to 2.82±0.63 mm after cataract surgery (p<0.001). ACD was 3.10±0.26 mm before cataract surgery, and it increased to 3.58±0.24 mm after cataract surgery (p<0.001).

DISCUSSION

The change in pupil shape according to the light in the environment, the adjustment of the visual clarity and the change in pupil size according to the person's mood has attracted the attention of researchers. Different systems have been developed to measure pupil size and shape. Usually, all these systems function on one principle: the eye is directly illuminated by a light source and the PD is then photographed using an infrared sensitive chamber.

In cataract surgery, pupil size and shape are factors that have an important effect on the success of the surgery. In addition, these factors have a crucial effect on retinal illumination and related three-dimensional vision. Thus, in the postoperative period, pupil size, and shape significantly affect visual functions.[6]

In this study, we examined dynamic and static pupillometry changes after uneventful phacoemulsification surgery. Based on the results, we concluded that PD decreases in dynamic and static conditions after uneventful cataract surgery. However, previous studies have reported different results for the effect of cataract removal surgery on PD. Sobaci et al. reported that cataract removal surgery had no effect on PD, shift, and shape.[7] The present study demonstrated a statistically significant change in pupil size and ACD following cataract surgery. After the surgery, mesopic PD changed by −9% and photopic PD by −12%. In addition, there was a +15% change in ACD.

Moreover, unlike the findings reported by Sobacı et al.[7] regarding changes in pupil size and shape following phacoemulsification surgery, several studies have reported that cataract surgery changes pupil shape and size. Kanellopoulos at al. reported PD reduction rates of −11% to −13% after cataract surgery.[3] These PD changes in the direction of shrinkage may be associated with increased AC depth and volume after removal of the bulky crystalline lens and replacement with a thin IOL.[8] Substituting a thinner IOL with a bulky crystalline lens may allow more freedom in the movement of the mitotic iris muscles, resulting in a smaller PD. In addition, it is possible that before cataract surgery, the bulky crystalline lens negatively affects iris movement. An optical coherence tomography of the anterior chamber image of a patient who underwent cataract surgery is shown in Figure 1. Before the cataract surgery (left), the anterior chamber volume was narrow, and the iris muscles were stuck. In addition, the PD was high owing to the posterior pushing of the bulky crystalline lens on the iris. After cataract surgery, ACD increased and PD decreased, and these findings were supported numerically. In another study by Kanellopoulos et al., the horizontal PD decreased by −0.27 mm, the vertical PD decreased by −0.32 mm, and the pupil flexibility reduced by 39%.[3] Few articles investigating changes in PD following cataract surgery have also reported postoperative PD decreases, with mechanical irritation of the uveal tissue.[3,4,9]

Moreover, in a study conducted by Yi et al., patients who underwent Intra Cameral Lens (ICL) implantation demonstrated a decrease in mesopic PD by 0.32 mm and photopic PD by 0.27 mm in the 3-month follow-up.[10] A decrease in pupillary contraction amplitude and mobility may have been due to field constriction.

Another possible reason for the reduction in PD after cataract surgery may be due to the higher IOL clarity and light transmittance than the cataractous lens.[4] Although exposed to the same light intensity, optic nerve fibers can be stimulated more in the postoperative period than in the cataracted state, resulting in further narrowing of the

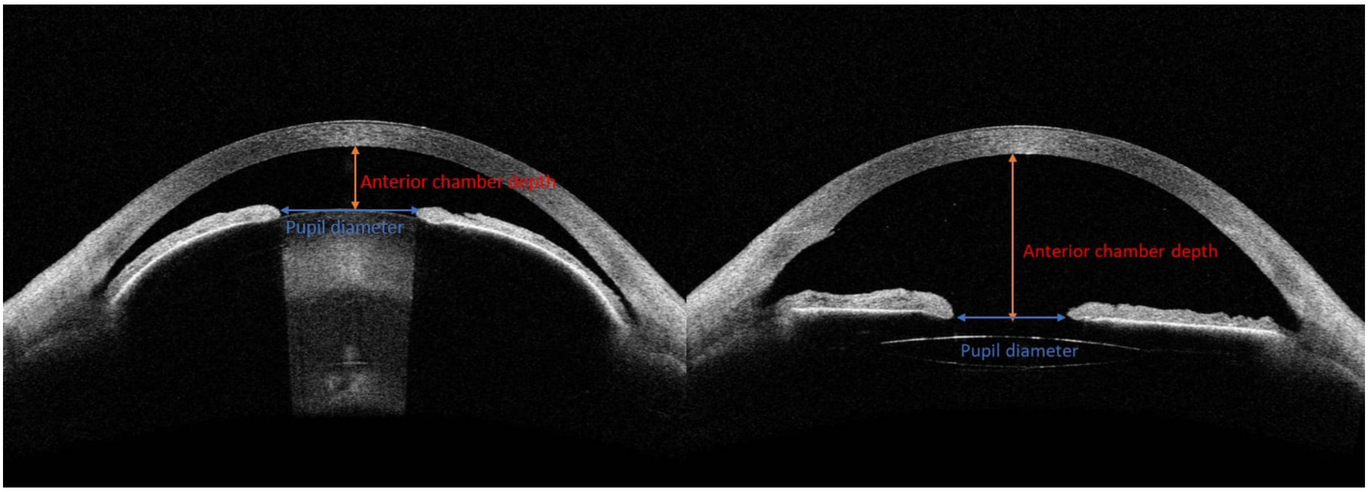

Figure 1: *Anterior chamber optical coherence tomography image showing decrease in PD with increase in anterior chamber volume and ACD before (left) and after cataract surgery (right).*

PD. However, the proportional decrease in photopic and scotopic PD suggests that the cause is more related to mechanical stress in the iris and increased ACD.

In conclusion, our findings show a statistically significant decrease in pupil size and a statistically significant increase in anterior chamber volume and ACD after cataract surgery. In addition, we found that cataract surgery has a constricting effect on pupil size and results in a smaller PD under dynamic and static conditions than in preoperative conditions. The following should be considered as the causes of PD change: wider range of motion of the miotic iris muscles owing to increased ACD and anterior chamber volume, mechanical irritation of the uveal tissue, postoperative anterior chamber reaction, topical drops used, or dysphotopsia.

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